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A DATA ACQUISITION AND PROCESSING SYSTEM FOR GUN INTERIOR BALLI--ETC(U)

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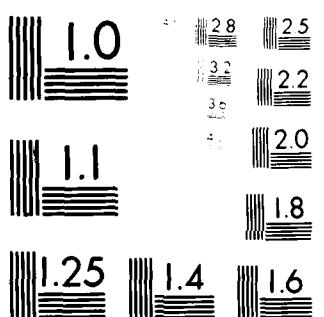
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**TECHNICAL REPORT**

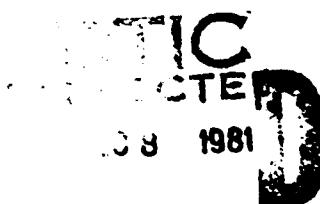
WSRL-0209-TR

**A DATA ACQUISITION AND PROCESSING SYSTEM FOR  
GUN INTERIOR BALLISTIC STUDIES**

(PART I)

A.R. RYE

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TECHNICAL REPORT

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A DATA ACQUISITION AND PROCESSING SYSTEM

FOR GUN INTERIOR BALLISTIC STUDIES

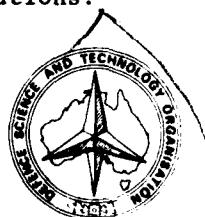
(Part 1)

A.R. Rye

10 May 72

S U M M A R Y

A data acquisition and processing system for use in the gun ballistic ranges of Propulsion Division, WSRL, is described. Adaptability and economy are achieved by the use of digital transient recorders interfaced to a Hewlett-Packard 9825A Desktop Computer. In one case, minor hardware changes were required. Flexible software has been developed, encoded in Hewlett-Packard's "HPL" programming language. Full software details are given for reference by system users wishing to make modifications.



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#### F O R E W O R D

This report includes details of a system developed to enable the acquisition and processing of gun interior ballistic data. This system uses a Hewlett-Packard 9825A Desktop Computer to control a range of peripheral devices. An alternative system controller, the Hewlett-Packard 85F Desktop Computer, is also available. The software used with the latter computer is quite dissimilar, and will be documented at a later date as Part 2 of this series.

The use of manufacturers' or trade names in this report does not constitute endorsement of any commercial product.

## I. INTRODUCTION

Gun Propulsion Research Group of Propulsion Division, WSRL has evaluated several approaches to the task of acquisition and processing of data from gun ballistic ranges. Overseas laboratories visited by the author in recent years use systems based on data transferral (in either analog or digital form) to magnetic media, with subsequent processing by a large central laboratory computer or by a dedicated minicomputer. However, recent advances in data acquisition and processing equipment mean that such a system is not necessarily the most efficient or economic. It was decided that the task of data handling at the two ranges operated by the Group at DRCS, and the portability required for operation at other sites, could best be met by a system containing flexible self-contained data acquisition units under the control of a programmable desktop computer. Such a system has successfully been put into operation at WSRL. Additional output capability has been achieved by the addition of a plotter and a small line-printer. Data storage and software access will be improved in the near future by incorporation of a diskette drive and a cartridge tape unit.

## 2. SYSTEM CONFIGURATION

### 2.1 System Control and Data Processing

These functions are fulfilled by a Hewlett-Packard HP9825A Desktop Computer, equipped with 23K bytes of user memory. This computer has certain features which suit it to the particular problems associated with the management of ballistic range data. In general, the task does not demand sophisticated software. The control and processing sequence is basically linear in operation, but large quantities of digital data have to be acquired from several sources and processed efficiently and flexibly. The HP9825A is a fast compact computer, and the availability of several types of compatible interface means that it may be readily incorporated into systems with different digital I/O requirements. Software for the HP9825A is written in Hewlett-Packard's programming language called HPL (ref.1). This language has strong similarities with ANSI BASIC and any programmer familiar with BASIC will rapidly learn HPL. The execution of the programs described in this report requires the installation of certain read-only memories (ROMs). These are for Advanced Programming, General I/O Programming, Extended I/O Programming, String Variable Programming, and HP9872 Plotter Programming. Programs used by the HP9825A are normally stored on tape cartridges, for which the HP9825A has its own internal tape drive. This drive is also used to access and store data. In addition, the computer includes a small internal thermal printer for written output. A useful feature of the HP9825A is that it has a number of programmer-definable keys (Special Function or "soft" keys) which are of value when the system is to be operated by personnel with limited knowledge of programming in HPL.

### 2.2 Graphic Display

Hard-copy graphics are obtained using a Hewlett-Packard 9872A Plotter. This plotter will accept paper up to A3 size and writes using any one of four user-selectable pens. This is a flexible device, which is controllable by many host computers as it has its own internal high-level language. It also responds to HPL commands from the HP9825A. It is connected to the host computer using its own IEEE-488 interface (ref.2).

### 2.3 Data Storage for Future Reference

This is accomplished using the internal cartridge tape unit of the HP9825A and designated data tapes. This method has certain programming limitations but has proved adequate. A Hewlett-Packard 9885M Diskette drive and HP9875A Cartridge Tape Unit will be incorporated into the system at a later date. These items will greatly enhance system flexibility.

### 2.4 Printed Output

The small thermal printer of the HP9825A computer is adequate for output during normal operation at the ballistic ranges, but is too small for general use or for listing of programs. An Epson MX-80 printer is connected to the computer when such usage is required, using its own IEEE-488 interface.

### 2.5 Data Acquisition Devices

Two types of digital transient recorder are available at DRCS for use with the system:

#### 2.5.1 Biomation 1015

This device (ref.3) is a four-channel unit with 1024 10-bit words available per channel. The minimum acquisition interval is 0.01 millisecond which is marginal, but acceptable, for the extremely rapid events monitored during gun firings. It uses a non-standard digital interface which is described in section 2.6. The Biomation 1015 has a small range of remotely controllable functions. This means that the operator has to use panel switches to initiate actions which can be software-controlled in some recorders of more recent design.

#### 2.5.2 Datalab DL2800

This multichannel unit (ref.4) consists of a functional controller, which sets parameters such as acquisition rates, trigger levels and operating mode, and up to eight memory modules which are effectively separate channels. Each memory has 4096 10-bit words and the minimum acquisition interval is 0.5 microsecond. This device is connected to the system controller by means of a digital interface which implements almost all of the transfer and control capabilities of the IEEE-488 interface standard (ref.2).

### 2.6 Interfaces

The HP9825A computer is connected to the Datalab DL2800, the plotter, the printer, and the diskette drive using the Hewlett-Packard 98034A HP-1B interface (ref.5), which is that company's implementation of the IEEE-488 standard. Up to fourteen peripheral devices can be controlled using this interface. The Biomation 1015 transient recorder is linked to the computer using a Hewlett-Packard 98032A 16-bit interface (ref.6). The connector terminating the cable from the HP98032A interface has been specifically configured to suit the format of the digital output terminal of the Biomation 1015 and a prototype projectile velocity counter. The specific details of this non-standard termination are included in reference 7.

## 2.7 Program Security and Protection

HPL has a facility to secure programs and prevent a user displaying them on the internal printer of the computer or its front-panel display area. This capability is not used for these programs. They are secured only against erasure by the physical locking of a tape-protection device on the tape cartridge. In the event of accidental erasure or damage to the tapes in routine use, master tapes are available for duplication as required.

## 3. SYSTEM OPERATION

This section is included to give an overview of the way the system functions as a whole. It is not intended to furnish detailed operating instructions.

### 3.1 System Connections

The current format of the system requires that phenomena monitored at the gun, such as the pressure and strain histories, projectile exit, and firing impulse, are recorded on one of the transient recorders. Transducers and detectors for events at the gun are connected to the recorder using specified signal conditioners and amplifiers. The transient recorder is connected to the computer using the appropriate interface. External events, such as bullet velocity downrange, are read from displays by the operator, and entered when requested using the computer keyboard.

### 3.2 Data Acquisition

The transient recorder controls, and those of ancillary equipment, are set to suitable values. The firing is executed, and the digital information is now available from the recorder's data store. The operator notes any velocity information required for keyboard entry to the computer.

### 3.3 Data Processing

The operator loads the appropriate tape cartridge into the HP9825A computer and turns the power on. All operations to load programs, set constants and define the functions of the "soft" keys are performed automatically. An operator instruction list is produced on the internal printer which outlines program operation and lists the actions performed by the "soft" keys. Such an instruction list is illustrated in figure 1. The operator enters information when prompted by the computer. The computer then inputs the digital data from the transient recorder under program control and performs certain calculations to adjust baselines and to convert the data into the required units. A Firing Summary is printed. The operator is then requested to use the "soft" keys to designate his output requirements. Typical output options include a printed pressure summary, or perhaps a plotted representation of the data. Examples of a firing summary and printed pressure summary, and a plotted pressure history, are included in figures 2 and 3 respectively. Figure 2 illustrates the "default" pressure summary, which is intentionally brief. This initial summary allows the user to determine the chronological location of the specific data he requires. He may then make simple software modifications to print or plot this information with higher resolution.

\*\*\*\*\*

This program is intended to draw data from a BIOMATION 1015.

It is designed for convenient repetitive operation.

Data entries are only required once, but can be entered or changed at will.

On successive runs, data keyed in earlier is retained by use of "CONTINUE" key without data entry.

Use of this key in this manner when the Firing Serial Number is requested will automatically increment that number by 1.

Keyboard data is limited to 16 characters per input line.

\*\*\*\*\*

NORMAL  
OUTPUT OPTIONS:

- +0 - No more O/P - start anew.
- +1 - Print short pressure summary.
- +2 - Single Plot (A4 paper)
- +3 - Double plot (A4 paper)
- +4 - Single plot (A3 paper)
- +5 - Four plots (A3 paper)
- +6 - Reset plot counter.
- +7 - Store data on tape.

\*\*\*\*\*

\*\*\*\*\*

MULTI-CHANNEL  
OPTIONS

- +8 - Gather next channel.
- +9 - Ignore next channel.

\*\*\*\*\*

MULTI-CHANNEL  
INPUT

This program can draw data from up to 4 channels of the BIOMATION 1015 recorder.

An extra output option starts acquisition of data from the next channel. This is done by pressing key(f8). The next channel can be rejected by using key(f9).

Print and plot output of multi-channel data is done in terms of pressure units, using the first timebase.

Key(f1) may be used with all channels to produce a print summary.

If you have used any of the plot options, the new data will also be plotted. The plot format last used will apply, and the new data will be overlaid on the first plot in a different colour

In multi-channel usage, once you record data on tape, you will be cautioned if you omit to record later data from other channels.

\*\*\*\*\*

Figure 1. Typical Instruction Listing

\*\*\*\*\*

\*\*\*\*\*

**MEF Lot 16/2/73****MEF Lot 16/2/73****FIRING NUMBER**

154

**FIRING NUMBER**

154

**Channel No. 1****Channel No. 1****Kistler Ser.#430**  
January 8, 1981**TIME PRESSURE**  
**(usec) (MPa)**

0	0.0
500	0.0
1000	26.3
1500	314.4
2000	68.7
2500	24.8
3000	10.6
3500	5.1
4000	2.0
4500	0.5
5000	0.0
5500	0.0
6000	0.0
6500	0.0
7000	0.0
7500	0.0
8000	0.0
8500	0.0
9000	0.0
9500	0.0
10000	0.0

\*\*\*\*\*

**Max. Pressure...**  
416.1 MPa

\*\*\*\*\*

**Muzzle Velocity.**  
883.1 m/s

\*\*\*\*\*

Figure 2. Typical Firing and Pressure History Summaries

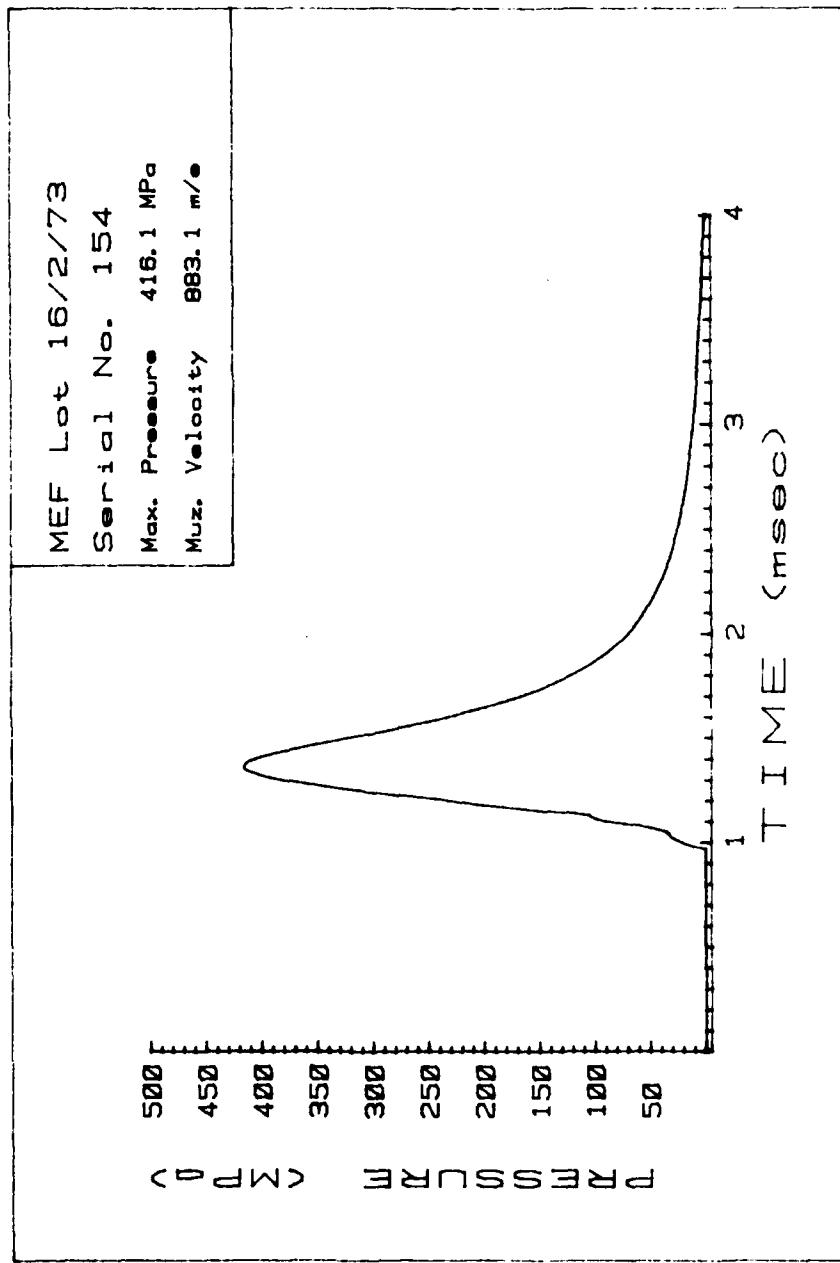


Figure 3. Typical pressure-time plot

### 3.4 Software Limitations

It is highly unlikely that normal usage of this system will include both the Biomation and Datalab Transient recorders. It is expected that the usual operating procedure will see the HP9825A associated with either one recorder or the other for considerable periods of time. Although it would be feasible to develop general software which would optionally control either transient recorder, significant advantage is gained by using two separate programs. The first program, designated "9825BI", is used when the HP9825A is connected to the Biomation 1015 transient recorder, while the second program "9825DL", is used with the Datalab instrument. The programs are essentially identical except for areas where consideration has to be given to the different absolute size of the memories of the two recorders, and their very different means of transmitting digital data. The existence of two programs poses no practical problem because of the normal association of the computer with only one of the recorders. The separation of the software into two programs leads to improved utilisation of data storage on magnetic tape. However, this means that Biomation and Datalab-sourced data should not be recorded on the same data tape. A third program, "9825PO", has also been developed which is used to access and analyse data obtained by either of the two previous programs and recorded on a tape cartridge. This program can only draw data from this source and thus has no formal data acquisition capability - it is for data processing only. This program is normally used in the laboratory or office environment to enable detailed examination of data previously obtained.

Listings of these three programs and associated explanatory notes are included in Appendices II, III, and IV respectively.

## 4. PROGRAM STRUCTURE

The structure of the three programs described in this paper is essentially the same and is quite straightforward. The programs are divided into three principal sections - a "driver" section, a group of "direct-execution" routines, and a group of "service" routines. A representative Flow Chart is illustrated in figure 4.

### 4.1 Driver Section

The driver section of each program is responsible for the setting up of initial conditions and for controlling the overall flow of the acquisition and processing sequence. Initial actions include the assignment of key variables and counters and the setting of program flags. The operator is prompted to enter any external data requirements, such as instrument settings and titling information. The program then initiates data acquisition, either from a transient recorder or from a tape cartridge. The operator is then prompted to use one of the output options actuated by the Special Function Keys (f0-f9). The functions of these keys have been summarised in the print-out illustrated in figure 1.

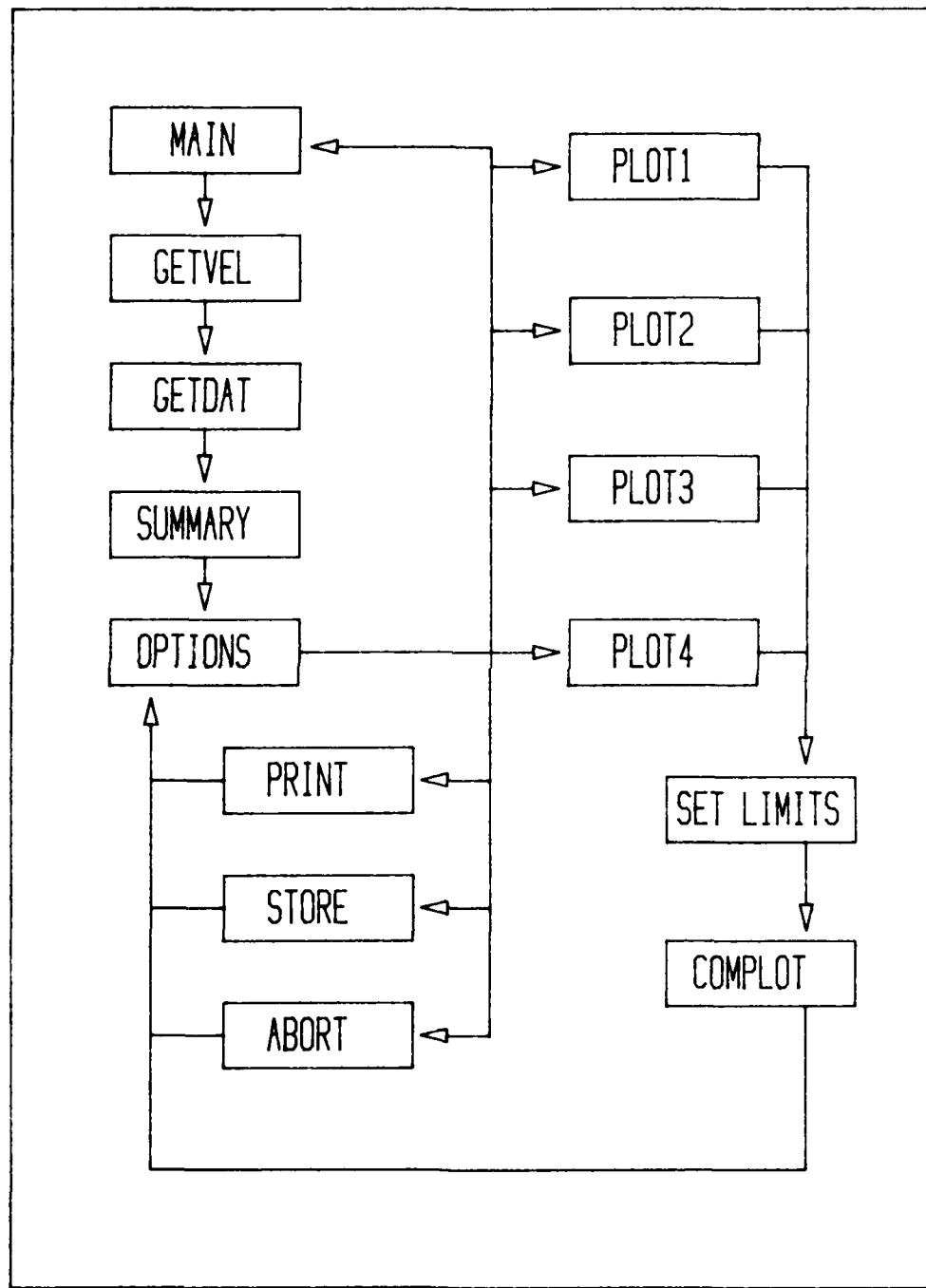


Figure 4. Representative Flow Diagram

#### 4.2 Direct-execution Routines

These routines perform the major part of the acquisition, processing and output functions of the program in use. Specifically, routines are included which:

- (a) Acquire projectile muzzle velocity. (GETVEL)
- (b) Acquire data from recorder or tape. (GETDAT)
- (c) Print data summary. (SUMMARY)
- (d) Execute plot framework. (COMPLOT)
- (e) Record firing data on tape cartridge. (STORE)
- (f) Skip unwanted channels or data. (ABORT)

#### 4.3 Service Routines

The service routines are responsible for the establishment of boundary conditions for the direct-execution routines and for the execution of certain administrative functions within the program. The tasks of these routines include:

- (a) Initialising the plotting areas specified. (PLOTn routines)
- (b) Establishment of upper limits for the plot axes. (SET LIMITS)
- (c) Issuing warnings for error conditions. (WARNING)
- (d) Control of print formats.

Routines (c) and (d) are administrative routines which are not included in the Flow Diagram (figure 4).

#### 4.4 Program Counters

Certain counters and temporary stores are used within the programs whose functions are not immediately obvious. These variables include:

- (a) D\$ - This variable acts as a general storage for alphanumeric input. Its value is normally transferred to another location after certain checks on its magnitude have been satisfied.
- (b) N - The number of the recorder channel currently being processed. This number also designates the plotter pen station associated with that channel.
- (c) Q - The total number of firings recorded on a data tape.
- (d) S - The total number of data files recorded on a data tape. One firing can generate as many as six files, depending on the number of channels in use.
- (e) T - The number of the data tape track in current use.
- (f) Y - Indicates which of two plot areas on a double plot page is to be used.
- (g) Z - Indicates which plot area on a four-plot page is to be used.

#### 4.5 Program Flags

Program flags 1 through 6 are used to alert the program logic to certain operating conditions. The flags have the following meanings when set:

- (a) Flag 1 - Multichannel mode in effect.
- (b) Flag 2 - Data has been plotted.
- (c) Flag 3 - Data has been recorded.
- (d) Flag 4 - Current channel has been plotted.
- (e) Flag 5 - Current channel has been recorded.
- (f) Flag 6 - Indicates Biomation-sourced data (Program 9825PO only).

The setting of flags 2 to 4 is conditional on flag 1. The operating mode determines the function of Flag 5. In single channel use, flag 5 is only encountered in the "set" condition if the user attempts to store firing data a second time. The computer issues a suitable warning to limit tape wastage. In the multichannel mode, flag 3 "set" and flag 5 "cleared" is a condition which indicates that an earlier channel was recorded, but that the current channel has yet to be stored. An appropriate warning is generated to prevent data loss.

## 5. CONCLUSIONS

### 5.1 General Comments

Three sets of software have been developed which are capable of controlling the acquisition of certain interior ballistic data from gun firings. Subsequent data processing establishes several output options including storage on magnetic tape, printing a data summary, and plotting in any of four output formats. These software packages have proved to be reliable and flexible in routine use, and represent a tested basis from which individual users can develop their own special-purpose programs.

### 5.2 Program Status

All three software packages have been extensively used, and all feasible modes of normal operation have been satisfactorily executed. The programs can be designated as "error-free" in all areas except:

- (a) external errors resulting from tape-drive malfunction;
- (b) sequential user errors such as attempts to execute multichannel options in the single channel mode;
- (c) errors resulting from user-alteration of variables and flag settings during program execution.

### 5.3 Future Development

The software will undergo development in two principal areas as ancillary equipment becomes available:

- (a) Electronic acquisition of projectile velocity.
- (b) Allowance for more detailed input of pressure-transducer calibration figures.
- (c) Incorporation of modifications to accept inputs relating to the timing of firing pin impact and bullet exit.

## 6. ACKNOWLEDGEMENTS

During the development of the software described in this report, constructive comment was received from several current and potential users. The author wishes to specifically acknowledge the contributions of Dr P.J. Carson, Mr K.H. Adams, Mr R.T. Hammond, all of GPR Group, and Mr C. Phillips, of AEI Workshops Group.

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3	Biomation	"Model 1015 Waveform Recorder Operating and Service Manual", Manual 0115-0100, February 1975.
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5	Hewlett-Packard Desktop Computer Division	"Hewlett-Packard 98034A HP-IB Interface Installation and Service Manual", Manual 98034-90000, May 1979.
6	Hewlett-Packard Desktop Computer Division	"Hewlett-Packard 98032A 16-Bit Interface Installation and Service Manual", Manual 98032-90000, May 1979.
7	Weapons Systems Research Laboratory	"Hewlett-Packard 98032A 16-Bit Interface Cable Allocations", Drawing PD8709, January 1981.
8	Kemeny, J.G. and Kurtz, T.E.	"Basic Programming", Wiley, New York, 1971.

## APPENDIX I

### THE HPL COMPUTING LANGUAGE

The Hewlett-Packard Language (HPL) is a non-standard programming language which has wide currency in the field of desktop computers because of the popularity of calculators manufactured by that company. HPL has many similarities to ANSI BASIC (ref.8). Many of the instructions are shortened versions of the BASIC equivalent and the execution of programs in HPL and BASIC is very similar. However, it is appropriate at this stage to emphasise the unique or unusual features of HPL.

#### 1. The Assignment Operator ( $\rightarrow$ )

HPL uses the horizontal arrow ( $\rightarrow$ ) to indicate the assignment operation. For example, the statement (A $\rightarrow$ B) means "store the value of the variable called A in a location assigned to the variable B". While this operation is performed in similar fashion by most computers, it is normally written in the reverse order. For example, BASIC or FORTRAN would use the statement (B=A) for this purpose. Multiple assignment statements of the form A $\rightarrow$ B $\rightarrow$ C are permitted in HPL.

#### 2. Multiple Statement Lines

HPL allows the use of several statements per line of program coding. Such statements are separated by a semi-colon and, with one or two exceptions, are executed strictly left-to-right.

#### 3. Conditional Statements

The "IF" statement takes a similar form to that used by other languages:

If (expression A) (conditional relationship) (expression B) ....

However, in HPL, if the relationship is satisfied, the rest of the current line, including any multiple statements, is executed. For example:

if A=B ; C>D ;  $\pi$  $\approx$ D $\rightarrow$ P

In the absence of instructions to continue elsewhere, the following line will then be executed. If the relationship is not satisfied, execution of the next line occurs.

#### 4. String Variables

HPL handles string variables (alphanumeric data) in a very similar fashion to BASIC. A string variable is denoted by the inclusion of the "\$" sign in its assignment (for example, A\$), and must be appropriately allocated by a prior dimension statement. Similar operations are permitted with string variables under HPL as with BASIC.

##### 5. Program Execution

HPL is similar to BASIC and other simple computing languages, in that the computer's processing unit handles execution one line at a time. Program lines are interpreted (translated into internal machine-language instructions) and executed sequentially. There is little similarity to the overall program compilation required, for example, by FORTRAN. This means that execution can be stopped either from the keyboard, or routinely during the program, and changes to the coding or to the values of variables made. This can be a very useful feature during the analysis of results, or to adjust incorrectly entered or acquired data.

## APPENDIX II

### PROGRAM LISTING AND USER NOTES FOR PROGRAM "9825BI"

```
0:  
1: "DRIVER for BIOMATION 1015 Program (9825BI)":  
2:  
3: deg;1→Z→Y;0→T  
4: dim M,T$[16],S$[16],V,G$[2,16],P$[2048],R[3]  
5: dim L[3],M[3],N$[11,9],D$[30],E$[16],Q,S  
6: "RUN":if flg3 and flg5=0;c11 'WARNING'(1)  
7: ""→D$;fxd 0;cfg 1,2,3,4,5;1→N;wti 0,2  
8: ent "FIRING PROGRAM TITLE?",D$  
9: if len(D$)>16;c11 'WARNING'(3);jmp -1  
10: if len(D$)≠0;D$→T$;""→D$  
11: ent "FIRING SERIAL NUMBER?",D$  
12: if len(D$)>16;c11 'WARNING'(3);jmp -1  
13: if len(D$)=0;str(val(S$)+1)→S$  
14: if len(D$)≠0;D$→S$;""→D$  
15: "MULTI?":ent "No. of BIO.1015 Channels?",M  
16: "RUN2":if flg3 and flg5=0;c11 'WARNING'(1)  
17: cfg 5;if flg1;1+N→N;if flg2;sfg 4  
18: ent "GAUGE TYPE (or COMMENT#1)?",D$  
19: if len(D$)>16;c11 'WARNING'(3);jmp -1  
20: if len(D$)≠0;D$→G$[1];""→D$  
21: ent "GAUGE SERIAL NO. (or COMMENT#2)?",D$  
22: if len(D$)>16;c11 'WARNING'(3);jmp -1  
23: if len(D$)≠0;D$→G$[2];""→D$  
24: ent "CHARGE AMP. SETTING (MPa/V)?",r1  
25: ent "VOLTS FULL SCALE (BIO.1015)?",F  
26: F*r1*10/1023→r4;if flg1;jmp 3  
27: ent "TIMEBASE SETTING (msec)?",r2  
28: c11 'GETVEL'  
29: c11 'GETDAT';if M>1;sfg 1  
30: "SUMMARY":fmt 1,2/,16"*/",2/  
31: wrt 16.1  
32: T$→D$;c11 'CENTRE'(1)  
33: c11 'CENTRE'(2);spc  
34: prt " FIRING NUMBER"  
35: S$→D$;c11 'CENTRE'(1);spc  
36: if flg1;fxd 0;"Channel No."&str(N)→D$;c11 'CENTRE'(1);spc  
37: G$[1]→D$;c11 'CENTRE'(1)  
38: G$[2]→D$;c11 'CENTRE'(1)  
39: wrt 16.1  
40: prt "Max. Pressure..."  
41: fmt 2,f9.1," MPa",/  
42: wrt 16.2,r3/10  
43: prt "Muzzle Velocity."  
44: fmt 3,f9.1," m/s"  
45: wrt 16.3,V;wrt 16.1;""→D$  
46: "OPTIONS":if flg4;c11 'COMPLOT'  
47: dsp "PRESS f-KEY FOR REQUIRED OUTPUT";stp ;jmp 0  
48:  
49: "DIRECT EXECUTION ROUTINES":  
50:  
51: "GETVEL":ent "MUZZLE VELOCITY (m/s)?",V  
52: ret
```

```

53: "GETDAT":0→r3→R;wti 4,226;for I=1 to 25
54: (band(1023,rdb(2))→r5)+R→R
55: fti (r5*r4)→P$[2I-1,2I];next I
56: R/25→R;for I=26 to 1024
57: (band(1023,rdb(2))-R)*r4→r5
58: if r5>r3;r5→r3
59: fti (r5)→P$[2I-1,2I];next I;if N=M;wti 4,228
60: ret
61: "PRINT":fmt 1,2/,16"*",2/;wrt 16.1
62: T$→D$;c11 'CENTRE'(1);c11 'CENTRE'(2)
63: spc ;prt " FIRING NUMBER"
64: S$→D$;c11 'CENTRE'(1);spc
65: if flg1;fxd 0;prt " Channel No."&str(N);spc
66: prt " TIME PRESSURE"
67: wrt 16,"(",char(12),"sec) (MPa) "
68: prt "-----"
69: fmt 4,f6.0,f9.1
70: for J=1 to 1024 by K
71: wrt 16.4,J*r2*1000,itf(P$[2J-1,2J]/10;next J
72: wrt 16.1
73: ""→D$;gto "OPTIONS"
74: "COMPILE":if flg2=0;c11 'SET LIMITS'
75: pen# N;if flg2;gto "GRAPH"
76: scl 0,M[1],0,L[1];wrt 705,"TL2"
77: xax -L[1]/100,M[2],0,M[1],0
78: line 0;wrt 705,"TL1.2"
79: xax -L[1]/100,M[3],0,M[1],0
80: line ;wrt 705,"TL1.2"
81: yax 0,L[2],0,L[1],0
82: line 0;wrt 705,"TL.5"
83: yax 0,L[3],0,L[1],0
84: line ;csiz 3,2,1,0
85: for I=L[2] to L[1] by L[2]
86: plt -M[1]/10,I,1;cplt 0,-.25
87: lbl str(I);next I
88: plt -M[1]/(7+6p1),L[1]/10,1
89: csiz 3,1,1,90;lbl "PRESSURE (MPa)"
90: csiz 3,2,1,0
91: for I=M[2] to M[1] by M[2]
92: plt I,-L[1]/15,1;cplt -.125,0
93: if I>=10;cplt -.5,0;if I>=100;cplt -.5,0
94: lbl str(I);next I
95: plt M[1]/4,-L[1]/(7+2p1),1
96: csiz 4,1,1;lbl "TIME"
97: csiz 4,1.5,1;lbl "(msec)"
98: "GRAPH":for I=1 to 1000
99: if I*r2>r7;jmp 2
100: plt I*r2,itf(P$[2I-1,2I])/10,-2;next I;pen
101: pen;cfg 4;if flg2;ret
102: csiz 3-p1,1.5,1
103: plt .6*M[1]→r4,(1.15-p1/4)*L[1]→r5,1
104: lbl T$;plt r4,r5-.08*L[1],1
105: lbl "Serial No. ",S$;fxd 1
106: plt r4,r5-.16*L[1],1;csiz 2.5,2,1
107: lbl "Max. Pressure ",r3/10," MPa"
108: plt r4,r5-.24*L[1],1
109: lbl "Muz. Velocity ",V," m/s";if flg1;sfg 2
110: ret

```

```
111: "STORE":"">D$;trk T;if flg5;c11 'WARNING'(2)
112: if flg3;gto "DATASTORE"
113: dsp "LOAD ",D$,"DATA TAPE; press 'CONT'";"">D$;stp
114: "CHECK#FILES":ldf 0,Q,S;if S-2*Q+M<=60;jmp 4
115: if T=0;1>T;jmp -1
116: wrt 16.1;prt "NOT ENOUGH SPACEFOR ALL CHANNELS";wrt 16.1
117: "NEW ">D$;0>T;jmp -4
118: "MARK TAPE":Q+1>Q;fdf S+1>S;mrk 1,2;mrk 1,100
119: S+1>S;M+1000>M;rcf S,M,T$,S$,V;M-1000>M;if flg1;sfg 3
120: "DATASTORE":r2>R[1];r3>R[2];F*r1/1023>R[3]
121: S+1>S;rcf 0,Q,S;fdf S;mrk 1,2130
122: rcf S,G$,P$,R[*];fdf S+1;mrk 1,2
123: sfg 5;gto "OPTIONS"
124: "ABORT":if flg3 and flg5=0;c11 'WARNING'(1)
125: if flg1;1+N>N
126: wti 4,226;for I=1 to 1024
127: rdb(2)>r5;next I;if N=M;wti 4,228
128: gto "OPTIONNN"
129:
130: "SERVICE ROUTINES":
131:
132: "PLOT1":psc 705;pclr;fxd 0;pen# 1
133: wrt 705,"IP 156,244,10173,7452"
134: scl 0,25,0,18;plt 0,0,-2
135: c11 'BOX'(14,12.5,25,18)
136: wrt 705,"IP 1758,1444,8973,6248"
137: c11 'COMPLOT'(.1);gto "OPTIONS"
138: "PLOT2":psc 705;pclr;fxd 0;pen# 1
139: -Z>Z;if Z>0;wrt 705,"IP 1718,1153,6544,4353"
140: if Z>0;c11 'COMPLOT'(0);gto "OPTIONS"
141: dsp "LOAD GRAPH PAPER; PRESS 'CONT'";stp
142: wrt 705,"IP507,358,7738,10358"
143: scl 0,18,0,25
144: plt 0,0,-2;c11 'BOX'(10,8.8,18,12)
145: plt 0,13,-2;c11 'BOX'(10,8.8,18,12)
146: wrt 705,"IP1718,6358,6544,9555"
147: c11 'COMPLOT'(0);gto "OPTIONS"
148: "PLOT3":psc 705;pclr;fxd 0;pen# 1
149: wrt 705,"IP571,357,15787,10389"
150: scl 0,38,0,25;plt 0,0,-2
151: c11 'BOX'(21,17.6,38,25)
152: wrt 705,"IP2176,1550,14187,9570"
153: c11 'COMPLOT'(.5);gto "OPTIONS"
154: "PLOT4":psc 705;pclr;fxd 0;pen# 1
155: if Y=1;2>Y;gto "Y=1"
156: if Y=2;3>Y;gto "Y=2"
157: if Y=3;4>Y;gto "Y=3"
158: if Y=4;1>Y;gto "Y=4"
159: "Y=1":dsp "LOAD GRAPH PAPER; PRSS 'CONT'";stp
160: wrt 705,"IP571,357,15787,10389"
161: scl 0,38,0,25
162: plt 0,0,1;c11 'BOX'(10,8.8,18,12)
163: plt 0,13,1;c11 'BOX'(10,8.8,18,12)
164: plt 20,0,1;c11 'BOX'(10,8.8,18,12)
165: plt 20,12,1;c11 'BOX'(10,8.8,18,12)
166: wrt 705,"IP1779,6371,6580,9574"
167: c11 'COMPLOT'(0);gto "OPTIONS"
```

```
168: "Y=2":wrt 705,"IP1779,1156,6590,4354";jmp -1
169: "Y=3":wrt 705,"IP9791,6368,14600,9580";jmp -2
170: "Y=4":wrt 705,"IP9795,1149,14600,4363";jmp -3
171: "SET LIMITS":1000*r2+r7 .
172: "0040010.1"→N$[1]
173: "0050010.1"→N$[2]
174: "0100010.2"→N$[3]
175: "0200020.5"→N$[4]
176: "0400051.0"→N$[5]
177: "0500051.0"→N$[6]
178: "1000102.0"→N$[7]
179: "2000205.0"→N$[8]
180: "40005010."→N$[9]
181: "50005010."→N$[10]
182: "80010020."→N$[11]
183: for I=1 to 11;I→J
184: if val(N$[I,1,3])>=r3/10;jmp 2
185: next I
186: if r2=.01;ent "PLOT BASELINE- 4,5,or 10 msec?",r7
187: for I=1 to 11;I→K
188: if val(N$[I,1,3])>=r7;jmp 2
189: next I
190: val(N$[J,1,3])→L[1];val(N$[J,4,6])→L[2]
191: val(N$[J,7,9])→L[3];val(N$[K,1,3])→M[1]
192: val(N$[K,4,6])→M[2];val(N$[K,7,9])→M[3];ret
193: "BOX":iplt 0,p4,2;iplt p3,0
194: iplt 0,-p4;iplt -p3,0,-1
195: iplt p1,p4,-2;iplt 0,p2-p4
196: iplt p3-p1,0,-1;ret
197: "WARNING":beep;if p1=2;jmp 4
198: if p1=3;jmp 4
199: dsp "LAST CHANNEL NOT STORED !!";wait 3000
200: dsp "Use (f7) to tape; or else 'CONT'";stp ;ret
201: beep;dsp "LAST CHANNEL ALREADY STORED";stp ;jmp 0
202: dsp "TOO LARGE";wait 1500;ret
203: "CENTRE":if p1=2;gto "U/L"
204: 8-int(len(D$)/2)→L;" "→E$[1,1];next I
205: for I=1 to L;" "→E$[I,I];next I
206: for I=1 to len(D$)
207: D${I,I}→E${I+L,I+L};next I
208: gto "E$OUT"
209: "U/L":for I=L+1 to len(E$)
210: "-"→E$[I,I];next I
211: "E$OUT":prt E$;ret
```

USER NOTES FOR PROGRAM "9825BI"

Line Number	Comments
4	Allocates memory for number of channels, title, serial number, velocity, two comment lines, pressure and miscellaneous constants.
6,7	Normal start point after initialisation, sets initial values. Designates interface number 2 (HP98032A) as data source.
13	Increments Serial Number with null data entry.
26	Ratio (applied volts/full scale volts) is expressed as a 10-bit word with full scale volts = 1023. 10-fold magnification is applied to make best use of integer-precision storage later.
51	"GETVEL" is written as a routine because it is planned to acquire this data electronically at a later date.
53-60	R is average baseline displacement of first 25 points. Because a 16-bit word is transferred from the interface, and only the first 10-bits are valid, the left-most 6 bits are "anded out". Data value 226 (decimal) starts the Biomation 1015 output sequence, while 228 interrupts that sequence and returns the recorder to its normal state.
74	"COMPLOT" is the common plotting routine used by all the available plot formats. The internal parameter (p1) is used to adjust the positions of labels to different page sizes and shapes.
111	"STORE" records data on magnetic tape cartridge.
119	1000 is added to M as a signal that the data is Biomation-sourced.
124	"ABORT" skips unwanted channels.
132	"PLOT1" sets up plot area for a single plot on A4 size paper.
138	"PLOT2" sets up plot area for a double plot on A4 size paper.
148	"PLOT3" sets up plot area for a single plot on A3 size paper.
154	"PLOT4" sets up plot area for four plots on A3 size paper.
171	"SET LIMITS" determines upper bounds for pressure and time scales for plotting purposes. Also determines major and minor tick intervals for plot axes, and labelling frequency.

186        0.01 msec is the minimum acquisition interval of the Biomation 1015. The user is given the option, in this case, of examining the first 400 or 500 points in more detail.

193        "BOX" is a routine that frames the plot area and sets aside labelling areas.

197        "WARNING" issues cautions during certain error conditions.

203        "CENTRE" places titles centrally on print tape and underlines where necessary.

APPENDIX III

PROGRAM LISTING AND USER NOTES  
FOR PROGRAM "9825DL"

```
0:  
1: "DRIVER for DATALAB DL2800 Program (9825DL)":  
2:  
3: deg;1→Z→Y;0→T  
4: dim M,T$[16],S$[16],V,G$[2,16],P$[8192],R[3]  
5: dim L[3],M[3],N$[11,9],D$[30],E$[16],Q,S  
6: "RUN":if flg3 and flg5=0;c11 'WARNING'(1)  
7: ""→D$;fxd 0;cfg 1,2,3,4,5;1→N;wti 0,2  
8: ent "FIRING PROGRAM TITLE?",D$  
9: if len(D$)>16;c11 'WARNING'(3);jmp -1  
10: if len(D$)≠0;D$→T$;"":→D$  
11: ent "FIRING SERIAL NUMBER?",D$  
12: if len(D$)>16;c11 'WARNING'(3);jmp -1  
13: if len(D$)=0;str(val(S$)+1)→S$  
14: if len(D$)≠0;D$→S$;"":→D$  
15: "MULTI?":ent "No. of DL2800 Channels?",M  
16: "RUN2":if flg3 and flg5=0;c11 'WARNING'(1)  
17: cfg 5;if flg1;1+N→N;if flg2;sfg 4  
18: ent "GAUGE TYPE (or COMMENT#1)?",D$  
19: if len(D$)>16;c11 'WARNING'(3);jmp -1  
20: if len(D$)≠0;D$→G$[1];""→D$  
21: ent "GAUGE SERIAL NO. (or COMMENT#2)?",D$  
22: if len(D$)>16;c11 'WARNING'(3);jmp -1  
23: if len(D$)≠0;D$→G$[2];""→D$  
24: ent "CHARGE AMP. SETTING (MPa/V)?",r1  
25: ent "VOLTS FULL SCALE (DL2800)?",F  
26: F*r1*10/1023→r4;if flg1;jmp 4  
27: sfg 13;dsp "TIMEBASE SETTING (&char(12)&"sec")?";ent "",r2  
28: if flg13=0;r2/1000→r2  
29: c11 'GETVEL'  
30: c11 'GETDAT';if M>1;sfg 1  
31: "SUMMARY":fmt 1,2/,16"**",2/  
32: wrt 16.1  
33: T$→D$;c11 'CENTRE'(1)  
34: c11 'CENTRE'(2);spc  
35: prt " FIRING NUMBER"  
36: S$→D$;c11 'CENTRE'(1);spc  
37: if flg1;fxd 0;"Channel No."&str(N)→D$;c11 'CENTRE'(1);spc  
38: G$[1]→D$;c11 'CENTRE'(1)  
39: G$[2]→D$;c11 'CENTRE'(1)  
40: wrt 16.1  
41: prt "Max. Pressure..."  
42: fmt 2,f9.1," MPa",/  
43: wrt 16.2,r3/10  
44: prt "Muzzle Velocity."  
45: fmt 3,f9.1," m/s"  
46: wrt 16.3,V;wrt 16.1;"":→D$  
47: "OPTIONS":if flg4;c11 'COMPILOT'  
48: dsp "PRESS f-KEY FOR REQUIRED OUTPUT";stp ;jmp 0  
49:  
50: "DIRECT EXECUTION ROUTINES":  
51:  
52: "GETVEL":ent "MUZZLE VELOCITY (m/s)?",V  
53: ret
```

```
54: "GETDAT":0→r3→R;for I=1 to 25
55: rdb(702)→r5;(rdb(702)→r5)+R→R;fti (r5*r4)→P$[2I-1,2I];next I
56: R/25→R;for I=26 to 4096
57: (rdb(702)*256+rdb(702)-R)*r4→r5
58: if r5>r3;r5→r3
59: fti (r5)→P$[2I-1,2I];next I;if N=M;rdb(702)→r5
60: ret
61: "PRINT":fmt 1,2/,16"**",2/;wrt 16.1
62: T$→D$;c11 'CENTRE'(1);c11 'CENTRE'(2)
63: spc ;prt " FIRING NUMBER"
64: S$→D$;c11 'CENTRE'(1);spc
65: if flg1;fxd 0;prt " Channel No."&str(N);spc
66: prt " TIME PRESSURE"
67: wrt 16,"(",char(12),"sec) (MPa) "
68: prt "-----"
69: fmt 4,f6.0,f9.1
70: for J=1 to 4096 by K
71: wrt 16.4,J*r2*1000,itf(P$[2J-1,2J]/10;next J
72: wrt 16.1
73: ""→D$;gto "OPTIONS"
74: "COMPLOT":if flg2=0;c11 'SET LIMITS'
75: pen# N;if flg2;gto "GRAPH"
76: scl 0,M[1],0,L[1];wrt 705,"TL2"
77: xax -L[1]/100,M[2],0,M[1],0
78: line 0;wrt 705,"TL1.2"
79: xax -L[1]/100,M[3],0,M[1],0
80: line ;wrt 705,"TL1.2"
81: yax 0,L[2],0,L[1],0
82: line 0;wrt 705,"TL.5"
83: yax 0,L[3],0,L[1],0
84: line ;csiz 3,2,1,0
85: for I=L[2] to L[1] by L[2]
86: plt -M[1]/10,I,1;cplt 0,-.25
87: lbl str(I);next I
88: plt -M[1]/(7+6p1),L[1]/10,1
89: csiz 3,1,1,90;lbl "PRESSURE (MPa)"
90: csiz 3,2,1,0
91: for I=M[2] to M[1] by M[2]
92: plt I,-L[1]/15,1;cplt -1.25,0
93: if I>=10;cplt -.5,0;if I>=100;cplt -.5,0
94: lbl str(I);next I
95: plt M[1]/4,-L[1]/(7+2p1),1
96: csiz 4,1,1;lbl "TIME"
97: csiz 4,1.5,1;lbl "(msec)"
98: "GRAPH":for I=1 to 4000
99: plt I*r2,itf(P$[2I-1,2I])/10,-2;next I;pen
100: pen;cfg 4;if flg2;ret
101: csiz 3-p1,1.5,1
102: plt .6*M[1]→r4,(1.15-p1/4)*L[1]→r5,1
103: lbl T$;plt r4,r5-.08*L[1],1
104: lbl "Serial No. ",S$;fxd 1
105: plt r4,r5-.16*L[1],1;csiz 2.5,2,1
106: lbl "Max. Pressure ",r3/10," MPa"
107: plt r4,r5-.24*L[1],1
108: lbl "Muz. Velocity ",V," m/s";if flg1;sfg 2
109: ret
```

```
110: "STORE":""→D$;trk T;if flg5;c11 'WARNING'(2)
111: if flg3;gto "DATASTORE"
112: dsp "LOAD ",D$,"DATA TAPE; PRESS 'CONT'";""·D$;stp
113: "CHECK/FILES":ldf 0,Q,S;if S-2^Q+M-17;jmp 4
114: it T=0;1→T;jmp -1
115: wrt 16.1;prt "NOT ENOUGH SPACEFOR ALL CHANNELS";wrt 16.1
116: "NEW "→D$;0→T;jmp -4
117: "MARK TAPE":Q+1→Q;fdf S+1→S;mrk 1,2;mrk 1,100
118: rcf S+1→S,M,T$,S$,V;if flgl;sfg 3
119: "DATASTORE":r2→R[1];r3→R[2];F*r1/1023→R[3]
120: S+1→S;rcf 0,Q,S;fdf S+1;mrk 1,8500
121: rcf S,G$,P$,R[*];fdf S+1;mrk 1,2
122: sfg 5;gto "OPTIONS"
123: "ABORT":if flg3 and flg5=0;c11 'WARNING'(1)
124: if flgl;1+N→N
125: for I=1 to 4096
126: rdb(702)+rdb(702)→r5;next I;if N=M;rdb(702)→r5
127: gto "OPTIONS"
128:
129: "SERVICE ROUTINES":
130:
131: "PLOT1":psc 705;pclr;fxd 0;pen# 1
132: wrt 705,"IP 156,244,10173,7452"
133: scl 0,25,0,18;plt 0,0,-2
134: c11 'BOX'(14,12.5,25,18)
135: wrt 705,"IP 1758,1444,8973,6248"
136: c11 'COMPLOT'(.1);gto "OPTIONS"
137: "PLOT2":psc 705;pclr;fxd 0;pen# 1
138: -Z→Z;if Z>0;wrt 705,"IP 1718,1153,6544,4353"
139: if Z>0;c11 'COMPLOT'(0);gto "OPTIONS"
140: dsp "LOAD GRAPH PAPER; PRESS 'CONT'";stp
141: wrt 705,"IP507,358,7738,10358"
142: scl 0,18,0,25
143: plt 0,0,-2;c11 'BOX'(10,8.8,18,12)
144: plt 0,13,-2;c11 'BOX'(10,8.8,18,12)
145: wrt 705,"IP1718,6358,6544,9555"
146: c11 'COMPLOT'(0);gto "OPTIONS"
147: "PLOT3":psc 705;pclr;fxd 0;pen# 1
148: wrt 705,"IP571,357,15787,10389"
149: scl 0,38,0,25;plt 0,0,-2
150: c11 'BOX'(21,17.6,38,25)
151: wrt 705,"IP2176,1550,14187,9570"
152: c11 'COMPLOT'(.5);gto "OPTIONS"
153: "PLOT4":psc 705;pclr;fxd 0;pen# 1
154: if Y=1;2→Y;gto "Y=1"
155: if Y=2;3→Y;gto "Y=2"
156: if Y=3;4→Y;gto "Y=3"
157: if Y=4;1→Y;gto "Y=4"
158: "Y=1":dsp "LOAD GRAPH PAPER; PRESS 'CONT'";stp
159: wrt 705,"IP571,357,15787,10389"
160: scl 0,38,0,25
161: plt 0,0,1;c11 'BOX'(10,8.8,18,12)
162: plt 0,13,1;c11 'BOX'(10,8.8,18,12)
163: plt 20,0,1;c11 'BOX'(10,8.8,18,12)
164: plt 20,12,1;c11 'BOX'(10,8.8,18,12)
165: wrt 705,"IP1779,6371,6580,9574"
166: c11 'COMPLOT'(0);gto "OPTIONS"
```

```
167: "Y=2":wrt 705,"IP1779,1156,6590,4354";jmp -1
168: "Y=3":wrt 705,"IP9791,6368,14600,9580";jmp -2
169: "Y=4":wrt 705,"IP9795,1149,14600,4363";jmp -3
170: "SET LIMITS":
171: "0040010.1"→N$[1]
172: "0050010.1"→N$[2]
173: "0100010.2"→N$[3]
174: "0200020.5"→N$[4]
175: "0400051.0"→N$[5]
176: "0500051.0"→N$[6]
177: "1000102.0"→N$[7]
178: "2000205.0"→N$[8]
179: "40005010."→N$[9]
180: "50005010."→N$[10]
181: "80010020."→N$[11]
182: for I=1 to 11;I→J
183: if val(N$[I,1,3])>=r3/10;jmp 2
184: next I
185: for I=1 to 11;I→K
186: if val(N$[I,1,3])>=4000*r2;jmp 2
187: next I
188: val(N$[J,1,3])→L[1];val(N$[J,4,6])→L[2]
189: val(N$[J,7,9])→L[3];val(N$[K,1,3])→M[1]
190: val(N$[K,4,6])→M[2];val(N$[K,7,9])→M[3];ret
191: "BOX":iplt 0,p4,2;iplt p3,0
192: iplt 0,-p4;iplt -p3,0,-1
193: iplt p1,p4,-2;iplt 0,p2-p4
194: iplt p3-p1,0,-1;ret
195: "WARNING":beep;if p1=2;jmp 4
196: if p1=3;jmp 4
197: dsp "LAST CHANNEL NOT STORED !!";wait 3000
198: dsp "Use (f7) to tape; or else 'CONT'";stp ;ret
199: beep;dsp "LAST CHANNEL ALREADY STORED";stp ;jmp 0
200: dsp "TOO LARGE";wait 1500;ret
201: "CENTRE":if p1=2;gto "U/L"
202: 8-int(len(D$)/2)→L;"'"→E$
203: for I=1 to L;" "→E$[I,I];next I
204: for I=1 to len(D$)
205: D$[I,I]→E$[I+L,I+L];next I
206: gto "E$OUT"
207: "U/L":for I=L+1 to len(E$)
208: "-"→E$[I,I];next I
209: "E$OUT":prt E$;ret
```

USER NOTES FOR PROGRAM "9825DL"

This program is essentially similar to "9825BI". Areas in which important differences occur are noted.

Line Number	Comments
4	Pressure array has to accommodate 4096 points, rather than 1024.
27,28	The DL2800's timebase unit is microseconds, rather than milliseconds. These lines are designed to accommodate this difference and to allow a common timebase - milliseconds.
54	This subroutine reflects the use of a different interface (HP98034A). The data treatment is similar to the previous program.
59	The reading of the end-of-data (EOD) sequence at the end of the acquisition cycle is essential to return the DL2800 to its quiescent state.

APPENDIX IV

PROGRAM LISTING AND USER NOTES  
FOR PROGRAM "9825PO"

```
0:  
1: "DRIVER for HP9825A Processing Only program (9825PO)":  
2:  
3: deg;1→Z→Y;0→T  
4: dim M,T$[16],S$[16],V,G$[2,16],P$[8192],R[3]  
5: dim H$[2,16],Q$[2048],S[3],A$[3],Q,S  
6: dim D$[20],E$[16],N$[11,9],L[3],M[3]  
7: "START":deg;1→Y→Z;dsp "DATA TAPE PROCESSING PROGRAM";wait 1500  
8: dsp "LOAD DATA TAPE; press 'CONT"';stp  
9: ent "CAN YOU SPECIFY YOUR TAPE FILE?",A$  
10: if cap(A$[1,1])="Y";1→N→r1;gto "RUN"  
11: ent "TRACK No. FOR FILE SEARCH?",T  
12: if T>1 or T<0;jmp -1  
12: trk int(T)→T  
13: dsp "TAPE SEARCH UNDER WAY...wait!"  
14: fmt 1,2/,16"**",2/  
15: "START SEARCH":ldf 0,Q,S;wrt 16.1  
16: fmt 2,3x,"Track ",f2.0,2/,16"**",2/  
17: 1→r1;wrt 16.2,T  
18: fmt 3,"File No. ",f3.0,/16c  
19: fmt 4,"Firing ",9c  
20: fmt 5,"Firing No.",/,16c  
21: fdf r1;idf r2,r2,r2,r3  
22: if r2=0 and r3=0;dsp "END-OF-FILE THIS TRACK";wait 3000;jmp 8  
23: if r2=0 and r3=2;r1+1→r1;jmp 2  
24: r1+1→r1;jmp -3  
25: ldf r1,M,T$,S$,V  
26: spc ;wrt 16.3,r1,T$  
27: if len(S$)<=9;wrt 16.4,S$  
28: if len(S$)>9;wrt 16.5,S$  
29: spc ;r1+1→r1;jmp -8  
30: ent "SEARCH OTHER TRACK?",A$  
31: if cap(A$[1,1])#"Y";1→N→r1;gto "RUN"  
32: if T=0;1→T;jmp 2  
33: if T=1;0→T  
34: trk T;gto "START SEARCH"  
35: "RUN":if N<r1;c11 'WARNING'(1)  
36: ""→D$;fxd 0;cfg 1,2,4,6;1→N  
37: ent "ENTER TRACK No:",T,"FILE No.?",Q  
38: trk T;0→r1  
39: fdf Q;ldf Q,M,T$,S$,V;if M>1000;M-1000→M;sfg 6  
40: r1+1→r1;fdf Q+r1;idf r2,r2,r2,r3  
41: if r2=0 and r3=2;r1-1→r1;jmp 2  
42: jmp -2  
43: "RUN2":if M>=1000 and flg1=0;c11 'WARNING'(3)  
44: Q+1→Q;if flg1;1+N→N;if flg2;sfg4  
45: if N>r1;c11 'WARNING'(3)  
46: if M>1;sfg1  
47: if flg6=0;ldf Q,G$,P$,R[*];4000→M;jmp 4  
48: ldf Q,H$,Q$,S[*];1000→M  
49: H$[1]→G$[1];H$[2]→G$[2];Q$→P$  
50: for I=1 to 3;S[I]→R[I];next I  
51: R[1]→r2;R[2]→r3;R[3]→r4
```

```
52: "SUMMARY":fmt 1,2/,16"*,2/
53: wrt 16.1
54: T$>D$;c11 'CENTRE'(1)
55: c11 'CENTRE'(2);spc
56: prt " FIRING NUMBER"
57: S$>D$;c11 'CENTRE'(1);spc
58: if flg1;fxd 0;"Channel No."&str(N)-D$;c11 'CENTRE'(1);spc
59: G$[1]>D$;c11 'CENTRE'(1)
60: G$[2]>D$;c11 'CENTRE'(1)
61: wrt 16.1
62: prt "Max. Pressure..."
63: fmt 2,f9.1," MPa",/
64: wrt 16.2,r3/10
65: prt "Muzzle Velocity."
66: fmt 3,f9.1," m/s"
67: wrt 16.3,V;wrt 16.1;"">D$
68: "OPTIONS":if flg4;c11 'COMPLOT'
69: dsp "PRESS f-KEY FOR REQUIRED OUTPUT";stp ;jmp 0
70:
71: "DIRECT EXECUTION ROUTINES":
72:
73: "PRINT":fmt 1,2/,16"*,2/;wrt 16.1
74: T$>D$;c11 'CENTRE'(1);c11 'CENTRE'(2)
75: spc ;prt " FIRING NUMBER"
76: S$>D$;c11 'CENTRE'(1);spc
77: if flg1;fxd 0;prt " Channel No."&str(N);spc
78: prt " TIME PRESSURE"
79: wrt 16,"(,char(12),,"sec) (MPa) "
80: prt "-----"
81: fmt 4,f6.0,f9.1
82: for J=1 to M by K
83: wrt 16.4,J*r2*1000,itf(P$[2J-1,2J]/10;next J
84: wrt 16.1
85: "">D$;gto "OPTIONS"
86: "COMPLOT":if flg2=0;c11 'SET LIMITS'
87: pen# N;if flg2;gto "GRAPH"
88: scl 0,M[1],0,L[1];wrt 705,"TL2"
89: xax -L[1]/100,M[2],0,M[1],0
90: line 0;wrt 705,"TL1.2"
91: xax -L[1]/100,M[3],0,M[1],0
92: line ;wrt 705,"TL1.2"
93: yax 0,L[2],0,L[1],0
94: line 0;wrt 705,"TL.5"
95: yax 0,L[3],0,L[1],0
96: line ;csiz 3,2,1,0
97: for I=L[2] to L[1] by L[2]
98: plt -M[1]/10,I,1;cplt 0,-.25
99: lbl str(I);next I
100: plt -M[1]/(7+6p1),L[1]/10,1
101: csiz 3,1,1,90;lbl "PRESSURE (MPa)"
102: csiz 3,2,1,0
103: for I=M[2] to M[1] by M[2]
104: plt I,-L[1]/15,1;cplt -1.25,0
105: if I>=10;cplt -.5,0;if I>=100;cplt -.5,0
106: lbl str(I);next I
107: plt M[1]/4,-L[1]/(7+2p1),1
108: csiz 4,1,1;lbl "TIME"
109: csiz 4,1.5,1;lbl " (msec)"
```

```
110: "GRAPH":for I=1 to M
111: if I*r2>r7;jmp 2
112: plt I*r2,itf(P$[2I-1,2I])/10,-2;next I;pen
113: pen;cfg 4;if flg2;ret
114: csiz 3-p1,1.5,1
115: plt .6*M[1]*r4,(1.15-p1/4)*L[1]*r5,1
116: lbl T$;plt r4,r5-.08*L[1],1
117: lbl "Serial No. ",S$;fxd 1
118: plt r4,r5-.16*L[1],1;csiz 2.5,2,1
119: lbl "Max. Pressure ",r3/10," MPa"
120: plt r4,r5-.24*L[1],1
121: lbl "Muz. Velocity ",V," m/s";if flg1;sfg 2
122: ret
123: "ABORT":Q+1→Q;if flg1;1+N→N
124: if N>r1;c11 'WARNING'(3)
125: gto "OPTIONS"
126:
127: "SERVICE ROUTINES":
128:
129: "PLOT1":psc 705;pclr;fxd 0;pen# 1
130: wrt 705,"IP 156,244,10173,7452"
131: scl 0,25,0,18;plt 0,0,-2
132: c11 'BOX'(14,12.5,25,18)
133: wrt 705,"IP 1758,1444,8973,6248"
134: c11 'COMPLOT'(.1);gto "OPTIONS"
135: "PLOT2":psc 705;pclr;fxd 0;pen# 1
136: -Z→Z;if Z>0;wrt 705,"IP 1718,1153,6544,4353"
137: if Z>0;c11 'COMPLOT'(0);gto "OPTIONS"
138: dsp "LOAD GRAPH PAPER; PRESS 'CONT'";stp
139: wrt 705,"IP507,358,7738,10358"
140: scl 0,18,0,25
141: plt 0,0,-2;c11 'BOX'(10,8.8,18,12)
142: plt 0,13,-2;c11 'BOX'(10,8.8,18,12)
143: wrt 705,"IP1718,6358,6544,9555"
144: c11 'COMPLOT'(0);gto "OPTIONS"
145: "PLOT3":psc 705;pclr;fxd 0;pen# 1
146: wrt 705,"IP571,357,15787,10389"
147: scl 0,38,0,25;plt 0,0,-2
148: c11 'BOX'(21,17.6,38,25)
149: wrt 705,"IP2176,1550,14187,9570"
150: c11 'COMPLOT'(.5);gto "OPTIONS"
151: "PLOT4":psc 705;pclr;fxd 0;pen# 1
152: if Y=1;2→Y;gto "Y=1"
153: if Y=2;3→Y;gto "Y=2"
154: if Y=3;4→Y;gto "Y=3"
155: if Y=4;1→Y;gto "Y=4"
156: "Y=1":dsp "LOAD GRAPH PAPER; PRESS 'CONT'";stp
157: wrt 705,"IP571,357,15787,10389"
158: scl 0,38,0,25
159: plt 0,0,1;c11 'BOX'(10,8.8,18,12)
160: plt 0,13,1;c11 'BOX'(10,8.8,18,12)
161: plt 20,0,1;c11 'BOX'(10,8.8,18,12)
162: plt 20,12,1;c11 'BOX'(10,8.8,18,12)
163: wrt 705,"IP1779,6371,6580,9574"
164: c11 'COMPLOT'(0);gto "OPTIONS"
165: "Y=2":wrt 705,"IP1779,1156,6590,4354";jmp -1
166: "Y=3":wrt 705,"IP9791,6368,14600,9580";jmp -2
167: "Y=4":wrt 705,"IP9795,1149,14600,4363";jmp -3
```

```
168: "SET LIMITS":1000*r2→r7
169: "0040010.1"→N$[1]
170: "0050010.1"→N$[2]
171: "0100010.2"→N$[3]
172: "0200020.5"→N$[4]
173: "0400051.0"→N$[5]
174: "0500051.0"→N$[6]
175: "1000102.0"→N$[7]
176: "2000205.0"→N$[8]
177: "40005010."→N$[9]
178: "50005010."→N$[10]
179: "80010020."→N$[11]
180: for I=1 to 11;I→J
181: if val(N$[I,1,3])>=r3/10;jmp 2
182: next I
183: if r2=.01;ent "PLOT BASELINE- 4,5,or 10 msec?",r7
184: for I=1 to 11;I→K
185: if val(N$[I,1,3])>=r7;jmp 2
186: next I
187: val(N$[J,1,3])→L[1];val(N$[J,4,6])→L[2]
188: val(N$[J,7,9])→L[3];val(N$[K,1,3])→M[1]
189: val(N$[K,4,6])→M[2];val(N$[K,7,9])→M[3];ret
190: "BOX":iplt 0,p4,2;iplt p3,0
191: iplt 0,-p4;iplt -p3,0,-1
192: iplt p1,p4,-2;iplt 0,p2-p4
193: iplt p3-p1,0,-1;ret
194: "WARNING":beep;if p1=2;jmp 4
195: if p1=3;jmp 4
196: dsp "LAST CHANNEL NOT STORED !!";wait 3000
197: dsp "Use (f7) to tape; or else 'CONT'";stp ;ret
198: beep;dsp "LAST CHANNEL ALREADY STORED";stp ;jmp 0
199: dsp "TOO LARGE";wait 1500;ret
200: "CENTRE":if p1=2;gto "U/L"
201: 8-int(len(D$)/2)→L;"'"→E$
202: for I=1 to L;"'"→E$[I,I];next I
203: for I=1 to len(D$)
204: D$[I,I]→E$[I+L,I+L];next I
205: gto "E$OUT"
206: "U/L":for I=L+1 to len(E$)
207: "-"→E$[I,I];next I
208: "E$OUT":prt E$;ret
```

USER NOTES FOR PROGRAM "9825PO"

This program is broadly similar to the previously listed programs. Its fundamental difference is that it draws its numerical data from a magnetic tape cartridge, not a transient recorder. Areas of significant difference are:

Line Number	Comments
3,4	Set up different storage areas for Biomation and Datalab-sourced data.
7-34	Enable the user to examine a data tape to ascertain its contents.
39	Check to see if data is Biomation-sourced.
48-51	Transfer Biomation data into common data storage location as required.
184	Allows examination of Biomation data acquired at maximum rate.

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Interior ballistics  
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Ranges (facilities)  
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Control equipment

b. Non-Thesaurus  
Terms

HP9825A computer  
HP85F computer

## 15 COSATI CODES

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## 16 SUMMARY OR ABSTRACT:

(if this is security classified, the announcement of this report will be similarly classified)

A data acquisition and processing system for use in the gun ballistic ranges of Propulsion Division, WSLR, is described. Adaptability and economy are achieved by the use of digital transient recorders interfaced to a Hewlett-Packard 9825A Desktop Computer. In one case, minor hardware changes were required. Flexible software has been developed, encoded in Hewlett-Packard's "HPL" programming language. Full software details are given for reference by system users wishing to make modifications.

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